



# **Nuclear Safety Issues for the Rare Isotope Accelerator**

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# Facility Classification



DOE Order 420.1A

**Accelerator**

DOE Order 420.2A

Facilities or portions thereof where nuclear safety order is applied are excluded

**Nuclear**

10 CFR 830

Accelerators / operations are excluded

**Hazard Category 3**

“only significant localized consequences”

**Hazard Category 2**

“significant onsite consequences”

➤ **Technical Safety Requirements**

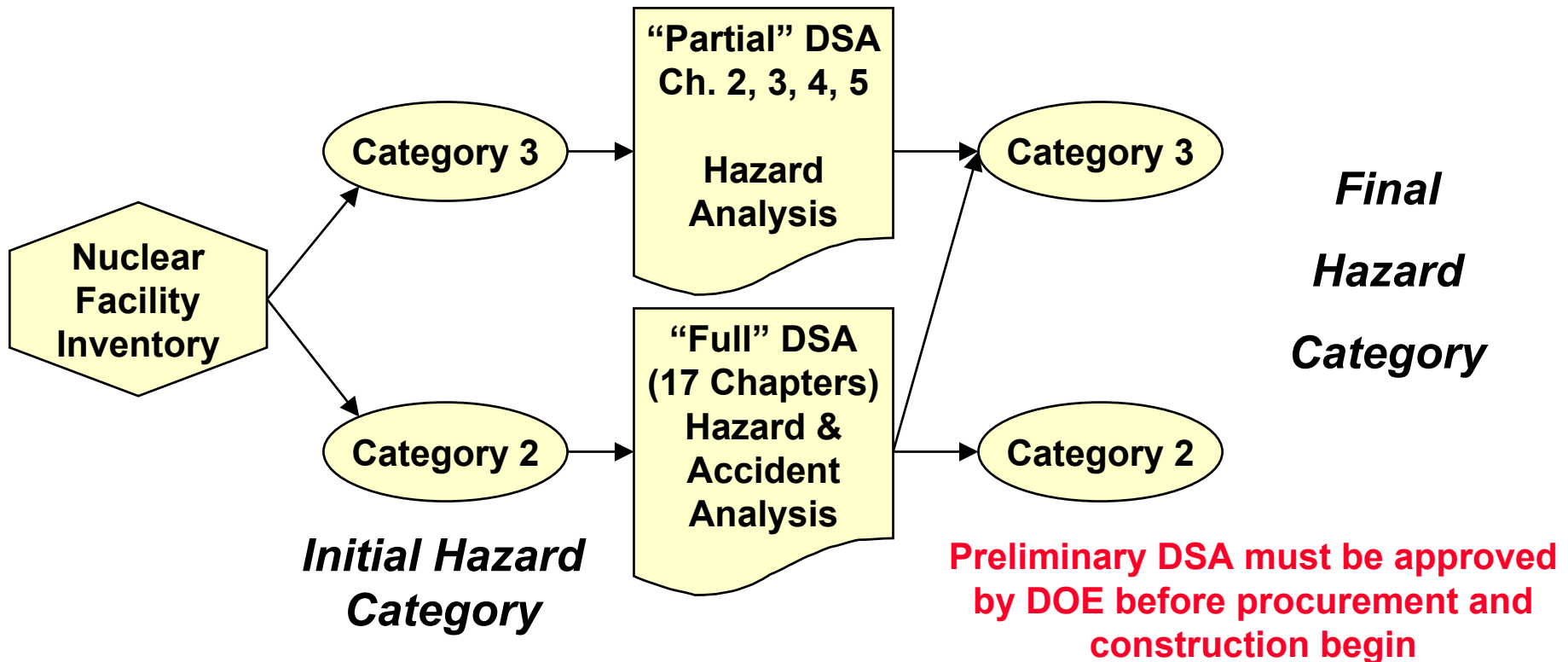
- **surveillance requirements**
- **increased recordkeeping**
- **operational readiness review**
- **enforcement provisions**

➤ **increased maintenance requirements**

➤ **external review by DNFSB**

**The case for the  
accelerator safety path  
must be made early**

# Nuclear Facility Approach



Hazard Category	3	2
Selected structures, systems, & components (SSCs)	Safety-significant	Safety-class
Seismic performance class	PC-2	PC-3
Specification (concrete structure)	ACI-318	ACI-349

ACI 318 – Gen Bldg Code – Reinforced Concrete  
 ACI 349 – Nuclear Safety Related Structures

DOE G 420.1-1 identifies standards for SS and SC

- ✓ Structures
- ✓ Ventilation system
- ✓ Process equipment
- ✓ Handling equipment
- ✓ Electrical
- ✓ I&C

# Segmentation, Phased Operation

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- **Segmentation: Division of a nuclear facility into independent segments where design features preclude accident phenomena in one segment from spreading to another segment**
  - **Advantage – Minimize the nuclear facility footprint**
  - **Spallation Neutron Source (ORNL) – only its target building is a candidate nuclear facility**
  - **At RIA, the isotopes are extracted – fundamentally different than SNS – further work needed on defining the nuclear segment boundary on the “back end”**
- **Phased Operation – Spallation Neutron Source**
  - **Commissioning and Low Power Operation – all systems covered as Accelerator facility**
  - **High Power Operation – Target building transitions to nuclear facility (Category 3, then Category 2), 6 months to 1 year after project completion (CD-4)**

# Flexibility and USQ

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- **RIA will field proton to uranium beams on various targets. Cannot analyze all potential configurations in the documented safety analysis.**
- **An Unreviewed Safety Question process would be followed for beam-target configurations not in the documented safety analysis**
  - **RIA-defined procedure – approved by DOE – in place prior to operations**
  - **If new configuration falls within the safety basis, then DOE approval is not required**

# Number of Isotopes to Consider for Category 2



Irradiation time

	1 day	7 days	28 days	1 year	20 years
All	94	94	94	94	94
< 1 E16 pps	10	13	17	25	34
Z < 93	10	11	13	19	25
Z < 82	3	3	5	10	16

**Ensuring RIA's inventory stays below  
Category 2 thresholds requires  
consideration of a small number of isotopes**

# Separate storage building for mitigating impact of long-lived isotopes



	Required production rate to reach Category 2 threshold		RIA proton beam  3 E15 pps
	1 month	20 years	
Ac-227	6.5 E13 pps	3.4 E11 pps	
Th-228	1.2 E14 pps	3.4 E12 pps	

- Periodic removal of targets/components with long-lived isotopes to a co-located storage building (Idea already discussed by RIA community)
- The hazard categorization of the storage building would be independent from the target building (segmentation)
- Having separate storage building increases the likelihood that the target building will remain Category 3

# ISOL Hand Calculations

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- Preliminary calculations
- Proton beam
- Monoenergetic cross sections (YIELDX)
- Uranium carbide target –
  - 0.43 Cat 3 fraction
  - 0.0044 Cat 2 fraction
  - For 5 g/cm<sup>2</sup> target, 1 month irradiation
- Calcium oxide target –
  - 2.9 Cat 3 fraction (mostly from <sup>32</sup>P)
  - 0.0082 Cat 2 fraction
  - For 5 g/cm<sup>2</sup> target, 1 month irradiation
- Copper beam stop – 20 year irradiation
  - 0.34 Cat 2 fraction



# Summary

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- **Need to make the case early to DOE in favor of accelerator safety**
- **SNS – Linac can be segmented as an accelerator facility**
- **Further work needed to determine nuclear segment boundary post-target**
- **Target building will likely be a Category 3 segment**
- **Co-located storage building may be needed as a Category 2 segment**
- **Sophisticated inventory calculations needed**